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FUNCTIONAL TESTING OF BALLOCN COMMAND RECEIVER. SKYHOOK 1975,(U)
AUG 76 H LEE, T PAPPAS N00014-75-C-1063
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6 Functional Testing Of Balloon Command Receiver.

SKYHOOK 1975

Performed Under
Contract N00014-75-C-1063
Requisition No. NR211-197/2-19/75
(465)

Amendment No. 1

For

Department of the Navy
Office of Naval Research
Arlington, VA 22217

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1. INTRODUCTION

Raven Industries was given the task of flight testing ten command receivers, designed by Dr. Williamson of the University of California at San Diego as part of Contract N00014-75-C-1063, Amendment No. 1. These tests were to consist of bench tests, simulated flight tests in the Raven altitude chamber, and three flight tests under actual conditions. Ten command receivers were supplied by Dr. Williamson for these tests. In addition, Dr. Williamson supplied a ground station for sending the termination commands. Additionally, a prototype digital ranging generator and readout were provided for the last flight of the series.

One unit was flown as a hitch-hike on the University of Wyoming flight No. 1389. This unit operated properly during the short daytime flight. The flight was terminated early due to failure of the prime experiment.

Three units were flown on Flight 1390. This was primarily a night time flight to determine cold effects on the command receivers. One unit failed to complete a command cycle due to temperature effects on the decoder circuit. The other units operated properly throughout the flight. Another was flown on Flight 1389 and two additional receivers were flown on Flight 1391. These latter units provided flight data in direct sunlight. Flight 1391 used to demonstrate the digital range read-out system developed by Dr. Williamson. The receivers and ranging system performed perfectly throughout the flight.

The audio retransmission was monitored periodically throughout all of the flights with no intermodulation being noted.

The original data transcribed in this report is on file at Raven Industries, Inc.

2. PREFLIGHT TESTS

Ten command receivers were received on March 30, 1976 from Lark Engineering. The command system was simultaneously received from Dr. Williamson. Bench checks were completed in April and the units scheduled into the altitude chamber for the first week of May. Data for each unit is contained in the tabulation. Three units were not operating properly when received and were returned to Dr. Williamson. One unit failed during bench testing. The other six units satisfactorily completed preliminary tests and were readied for flight testing.

Tables 1 thru 10 contain bench test data for the units.

3. FLIGHT TESTING

3.1 Flight 1389

Flight 1389 was a flight for the University of Wyoming. Command receiver, S/N 76-002, was flown as an add-on experiment on this flight. The flight was launched at 1110Z on 27 June 1976. Tests were conducted throughout the flight to verify receipt of the terminate command and to check the ranging capability of the receiver. The method described by Dr. Williamson of observing the time delay of the round trip of the transmitted square wave was used. Table 11 shows the comparison of ranging in this fashion and the Raven ranging system. It should be remembered that the sweep timing on an oscilloscope is $\pm$ 5% and a combination of trace jitter and operator judgement will introduce additional errors. With these considerations, the Williamson receiver shows good correlation with the Raven system.

Graph #1 shows the temperature profile seen by the receiver on this flight. Due to failure of the primary scientific experiment, the flight was terminated at 1706Z.

Based on a preliminary examination of the data from this flight it was decided to fly the next group of receivers as a night flight to observe the effects of cold temperatures on the receivers.

One anomaly was noted on the flight line during launch preparation: the command receiver would issue a squib fire command if the Raven walkie-talkies were used in close proximity to the test receiver.

3.2 Flight 1390

Flight 1390 was launched at 0251Z on 7 July 1976 at Sioux Falls, South Dakota. The flight was flown specifically to test three Williamson command receivers, Serial Numbers 76-006, 76-007, and 76-008. Due to upper wind considerations a float altitude of 84,000 feet was chosen as most desirable. A Raven 100,000 ft^3 balloon was used for the flight.

At approximately 0830Z, receiver 76-008 failed to accept the terminate command from the automatic command unit. No attempt was made to use a signal generator to sweep outside the frequency range of the automatic command unit. The temperature inside the command receiver was approximately -28°C at this time. At 1430Z the temperature was up to -25°C and the unit would accept a terminate command. The unit continued to operate properly throughout the remainder of the flight.

Units 76-006 and 76-007 operated properly throughout the flight. Table 12 shows the correlation of range data from the Williamson receivers with the Raven range data. The range on this flight was determined by observing the delay time on the oscilloscope.

Graphs 2, 3, & 4 show the temperature vs. time curve for these receivers.

3.3 Flight 1391

Flight 1391 was delayed for approximately two weeks to allow Dr. Williamson to complete his prototype digital range readout. Dr. Williamson arrived in Sioux Falls on Wednesday, July 28. The digital readout system was installed and checked out on July 28 and 29. Surface wind conditions were such that the flight was launched on the morning of July 30. The command and ranging system operated properly and the digital system produced a readout within ± 5 nautical miles of the Raven system throughout the flight. Receivers 76-002 (a reflight as previously flown on 1389), 76-009 and 76-010 were flown on this flight. The flight was terminated at 2100Z due to weather build-up in the downrange recovery area.

The flight was a complete success and proved the capability of the digital readout system when returned on an IRIG channel "E" VCO. The command and range data do not require a wide band system but can be time-shared by a multiplex system. This flight also tested the portable command system developed by Dr. Williamson. This unit consisted of a small battery powered sweep oscillator operating into a General Electric "PE" series Handi-Talkie. The total output power of the Handi-Talkie was five watts. The unit successfully commanded the receiver when the balloon was down to an altitude of 45,000 feet at a range of 100 nautical miles.

Table 13 shows the correlation of range as read by the Williamson system and the Raven TRAC system. As can be seen, range data agreed within ± 5 nautical miles in most cases. The data on receiver Serial No. 76-002 reflects the noise and jitter problems inherent in attempting to bring the range data back on a 40 KHZ ± 7.5% deviation VCO. The lower frequency VCO cannot provide sufficient bandwidth to operate the ranging system with the present signal to noise ratio. Conversations with Dr. Williamson has indicated he will change the op amp gain in his retransmission isolator from 1 to 9. This should improve the S/N ratio and allow operation on a mid-frequency VCO.

Graphs 5 & 6 show the temperatures recorded in the receivers during the flight. Receiver S/N 76-009 is not represented since a conversion constant from voltage to temperature is unavailable for this receiver. It should be noted that receiver S/N 76-002 was wrapped differently than the others flown on this flight. The mylar supplied by Dr. Williamson was covered with Raven furnished mylar. The other two units had only Raven furnished mylar. The Williamson mylar had aluminum foil on both sides while the Raven furnished had mylar only on the outside.

4. CONCLUSIONS & RECOMMENDATIONS

4.1 Conclusions

The Williamson receivers exhibited a 40% failure rate during bench and lab tests. This is probably due to two factors: (1) these were the first units built by this manufacturer and a learning curve is involved; and (2) the units probably were not aged to catch infant mortality. Since all of the units passed the manufacturer's acceptance testing the aging factor seems most probable.

One unit had an apparent failure during the flight which was due to temperature. No tests were conducted by Raven to determine what components were drifting or changing, however, some data which will help localize the problem is available:

(a) The command receiver was operating throughout the flight as demonstrated by the fact that ranging was operable.

(b) The L144AP quad op-amp IC was operating since it is used to isolate the audio (ranging) signal from the phase lock-loop (PLL) used for the command circuit.

(c) The unit returned to an operable condition as it warmed up.

(d) No attempt was made to command the unit by sweeping over a wider range than provided by the automatic unit.

The other five units, Serial Nos. 76-002, 76-006, 76-007, 76-010, and 76-011 all operated properly and indicated that they would continue to do so to the radio horizon. The oscilloscope method of ranging demonstrated a capability of indicating range of the balloon within ± 5 miles with a minimum of special equipment but does require a technician with an adequate background in oscilloscope techniques.

The automatic digital readout provided an accuracy of ± 5 nautical miles and could be operated by a minimally trained person. The basic investment in equipment would be more than off-set by this ease of operation. The capability of ± 0.5 nautical mile accuracy will probably be realized by the change in gain and S/N ratio improvement previously discussed.

These units were intended to be a low-cost means of determining control command. The six units flown by Raven on Flights 1389, 1390, and 1391 demonstrated this capability. No intermodulation from ground stations were noted, however, the flights all took place over sparsely populated areas with few radio and T.V. stations.

4.2 Recommendations

The tests conducted by Raven prompted several recommendations involving safety of personnel on the flight line and operability of the receivers. These are discussed individually in the following paragraphs.

4.2.1 Flight Line Safety

It was discovered during the tests that the 100 watt GE command transmitter would trigger any command receiver regardless of the frequency of the receiver if it was within close proximity of the unit. Also, the two watt and five watt Handi-Talkie's used by Raven on 149.4 MHz would fire any of the units when used for communication on the flight line. This could result in a flight-line termination during the launch procedure. Either a complete radio silence during launch must be maintained or a means of desensitizing or by-passing the critical components (receiver front end, PLL, SCR's) must be found. The danger to personnel in event of a flight line abort requires a solution to this problem.

4.2.2 Command Receiver Bandwidth

The problem demonstrated by Serial No. 76-008 can probably best be solved by either of two solutions. The components of the PLL frequency determining network can be replaced with less temperature sensitive components and a thermistor inserted to stabalize the circuit or the sweep range of the ground station can be broadened. The first solution appreciably increases the cost of each individual receiver which is undesirable in this case. The second solution has an initial cost for components and testing but no follow-on costs.

4.2.3 Component Burn-In Prior to Acceptance Test

The failure of four out of ten units received by Raven from Lark Electronics indicates that a multi-hour burn-in of each unit prior to final acceptance testing is required. The exact duration of this burn-in and any off-on cycling required was not within the scope of the Raven contract, therefore, no exact recommendations can be given at this time.

4.2.4 Command Transmitter Power Supply

The lead-acid Gel-Cell supplied by Dr. Williamson for powering the command transmitter was not adequate for operating the system for bench tests or for ranging and commanding a flight of 18-20 hours without frequent recharging. To avoid confusion and possible error during a flight, the battery should be used only for emergency or portable operation in a tracking aircraft. A laboratory supply capable of 30 amp output and a reasonable regulation should be used for all base-station operations.

4.2.5 Ranging & Retransmission

To provide good ranging capability as well as a voice retransmission capability, the VCO or multiplex capability provided in the transmitter on the flight package must have a pass-band of at least 2 KHz.

TABLE 1

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-001

TEST DATA

	BENCH	CHAMBER Simulated Solar Load	CHAMBER -55°C Cold
Center Frequency	NA		
Sensitivity With Filter	NA		
Sensitivity w/o Filter	NA		
Temperature Voltage	1.61		
Audio Voltage	.88		
Battery Voltage	4.11		
Squib Voltage	12.71		
Current			
Audio P-P (5 KHz dev)	NA		
Squib Delay (Sec)	NA		

Tested By: HL

Date: 3/31/76

COMMENTS: Unit had low voltages on the temperature and audio lines indicating a failure of the internal voltage regulator. No further tests were conducted. Unit was returned to Dr. Williamson.

TABLE 2

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-002

TEST DATA

	BENCH	CHAMBER Simulated Solar Load	CHAMBER -55°C Cold
Center Frequency	138.5391	138.541	138.542
Sensitivity With Filter	0.4uv	0.25uv	0.4uv
Sensitivity w/o Filter	0.4uv	NA	NA
Temperature Voltage	4.69	3.98	1.82
Audio Voltage	2.37	2.35	2.37
Battery Voltage	4.16	4.08	4.01
Squib Voltage	12.5	12.13	12.27
Current	NA	19 MA	19 MA
Audio P-P (5 KHz dev)	NA	.9	1.0
Squib Delay (Sec)	28	23	23
Tested By:	EE	CE	CE
Date:	4/21/76	6/28/76	6/28/76

COMMENTS: Unit appears good. Will replace outside foil per telecon with Dr. Williamson. Fly as add-on flight 1389.

TABLE 3

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-003

TEST DATA

	BENCH	CHAMBER: Simulated Solar Load	CHAMBER: -55°C Cold
Center Frequency	138.8387		NA
Sensitivity With Filter	0.3uv		NA
Sensitivity w/o Filter	0.3uv		NA
Temperature Voltage	4.65		2.94
Audio Voltage	2.22		2.20
Battery Voltage	4.17		4.08
Squib Voltage	12.6		12.3
Current	NA		NA
Audio P-P (5 KHz dev)	NA		NA
Squib Delay (Sec)	25		24

Tested By: EE

Date: 4/21/76

COMMENTS: After three hour cold soak squib fired without command and would remain in fired condition at turn-on even after return to room temperature. No further tests were conducted. Unit was returned to Dr. Williamson for evaluation.

TABLE 4

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-005

TEST DATA

		CHAMBER	
	BENCH	Simulated Solar Load	-55°C Cold
Center Frequency - MHZ	138.5362		
Sensitivity With Filter	1.0uv		
Sensitivity w/o Filter	1.0uv		
Temperature Voltage	4.81		
Audio Voltage	2.47		
Battery Voltage	4.15		
Squib Voltage	12.5		
Current	NA		
Audio P-P (5 KHz dev)	NA		
Squib Delay (Sec)	NA		

Tested By: EE

Date: 4/21/76

COMMENTS: Receiver sensitivity was twice the vendor (Plectron) specification value of 0.5uv max. No further tests were conducted. Unit was returned to Dr. Williamson for evaluation.

TABLE 5

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-006

TEST DATA

	BENCH	CHAMBER Simulated Solar Load	CHAMBER -55°C Cold
Center Frequency	138.838	138.840	138.840
Sensitivity With Filter	0.42uv	0.25uv	0.3uv
Sensitivity w/o Filter	0.4uv	NA	NA
Temperature Voltage	4.89	3.99	1.68
Audio Voltage	2.39	2.38	2.35
Battery Voltage	4.18	4.10	4.15
Squib Voltage	12.6	12.38	12.51
Current	NA	20 ma	20 ma
Audio P-P (5 KHz dev)	NA	1.2V	1.2V
Squib Delay (Sec)	18	18	17

Tested By: EE

Date: 4/21/76

COMMENTS: Unit flown on Flight 1390

TABLE 6

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-007

TEST DATA

	BENCH	CHAMBER Simulated Solar Load	CHAMBER -55°C Cold
Center Frequency	138.5396	1385.540	138.540
Sensitivity With Filter	0.35uv	NA	NA
Sensitivity w/o Filter	0.4uv	0.18uv	0.2uv
Temperature Voltage	4.87	3.77	1.45
Audio Voltage	2.45	2.43	2.38
Battery Voltage	4.19	4.0	3.81
Squib Voltage	12.57	12.03	11.48
Current	NA	20 MA	20 MA
Audio P-P (5 KHz dev)	NA	1.1V	1.2V
Squib Delay (Sec)	20	18	17
Tested By:	HL	CE	CE
Date:	3/30/76	6/29/76	6/29/76

COMMENTS: Unit flown on Flight 1390

TABLE 7

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-008

TEST DATA

	BENCH	CHAMBER Simulated Solar Load	CHAMBER -55°C Cold
Center Frequency	138.5391	138.540	138.540
Sensitivity With Filter	NA	NA	NA
Sensitivity w/o Filter	0.38uv	.18uv	.2uv
Temperature Voltage	4.98	3.77	1.45
Audio Voltage	2.54	2.43	2.38
Battery Voltage	4.18	4.00	3.81
Squib Voltage	12.6	12.03	11.48
Current	NA	20 MA	20 MA
Audio P-P (5 KHz dev)	NA	1.2	1.1
Squib Delay (Sec)	18	18	17
Tested By:	EE	CE	CE
Date:	4/21/76	6/30/76	6/30/76

COMMENTS: Flown on Flight 1390

TABLE 8

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-009

TEST DATA

	BENCH	CHAMBER Simulated Solar Load	CHAMBER -55°C Cold
Center Frequency	138.837	138.841	138.842
Sensitivity With Filter	NA		
Sensitivity w/o Filter	0.35uv	.18uv	.3uv
Temperature Voltage	5.0	3.83	2.30
Audio Voltage	2.50	2.47	2.44
Battery Voltage	3.96	4.12	4.08
Squib Voltage	11.94	12.30	12.40
Current	20 MA	18 MA	18 MA
Audio P-P (5 KHz dev)	1.1	1.0	1.1
Squib Delay (Sec)	21	21	21
Tested By:	CE	CE	CE
Date:	6/11/76	7/9/76	7/9/76

COMMENTS: Flown on Flight 1391

TABLE 9

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-010

TEST DATA

	BENCH	CHAMBER Simulated Solar Load	CHAMBER -55°C Cold
Center Frequency	138.5384	138.540	138.540
Sensitivity With Filter	0.38uv	.3uv	.3uv
Sensitivity w/o Filter	0.38uv	.3uv	.3uv
Temperature Voltage	4.92	3.92	1.57
Audio Voltage	2.45	2.42	2.39
Battery Voltage	4.21	4.08	3.90
Squib Voltage	12.6	12.20	11.60
Current	NA	15 MA	15 MA
Audio P-P (5 KHz dev)	NA	.9	1.1V
Squib Delay (Sec)	19	19	19

Tested By: EE

Date: 4/21/76

COMMENTS: Unit was flown on Flight 1391

TABLE 10

WILLIAMSON COMMAND RECEIVER DATA

Serial No. 76-011

TEST DATA

	BENCH	CHAMBER Simulated Solar Load	CHAMBER -55°C Cold
Center Frequency	138.533		
Sensitivity With Filter	NA		
Sensitivity w/o Filter	0.4uv		
Temperature Voltage	4.66		
Audio Voltage	2.30		
Battery Voltage	4.17		
Squib Voltage	12.5		
Current	NA		
Audio P-P (5 KHz dev)	NA		
Squib Delay (Sec)	31		

Tested By: EE

Date: 4/21/76

COMMENTS: Squib delay was greater than the 30 sec specified by Dr. Williamson. Unit was returned to Dr. Williamson for evaluation. No further tests were conducted.

TABLE 11

Flight test range and command check data

Flight 1389 Williamson Command Receiver

SLANT RANGE (NAUTICAL MILES)

Time Z	Williamson	Raven	Squib Delay Time
1110	5	5	29 sec
1130	11	10	
1200	33	37	
1230	NA	45	29 sec
1300	NA	37	
1330	33	28	25 sec
1400	33	28	29 sec
1430	60	54	29 sec
1500	77	78	29 sec
1530	100	103	30 sec
1600	126	122	29 sec

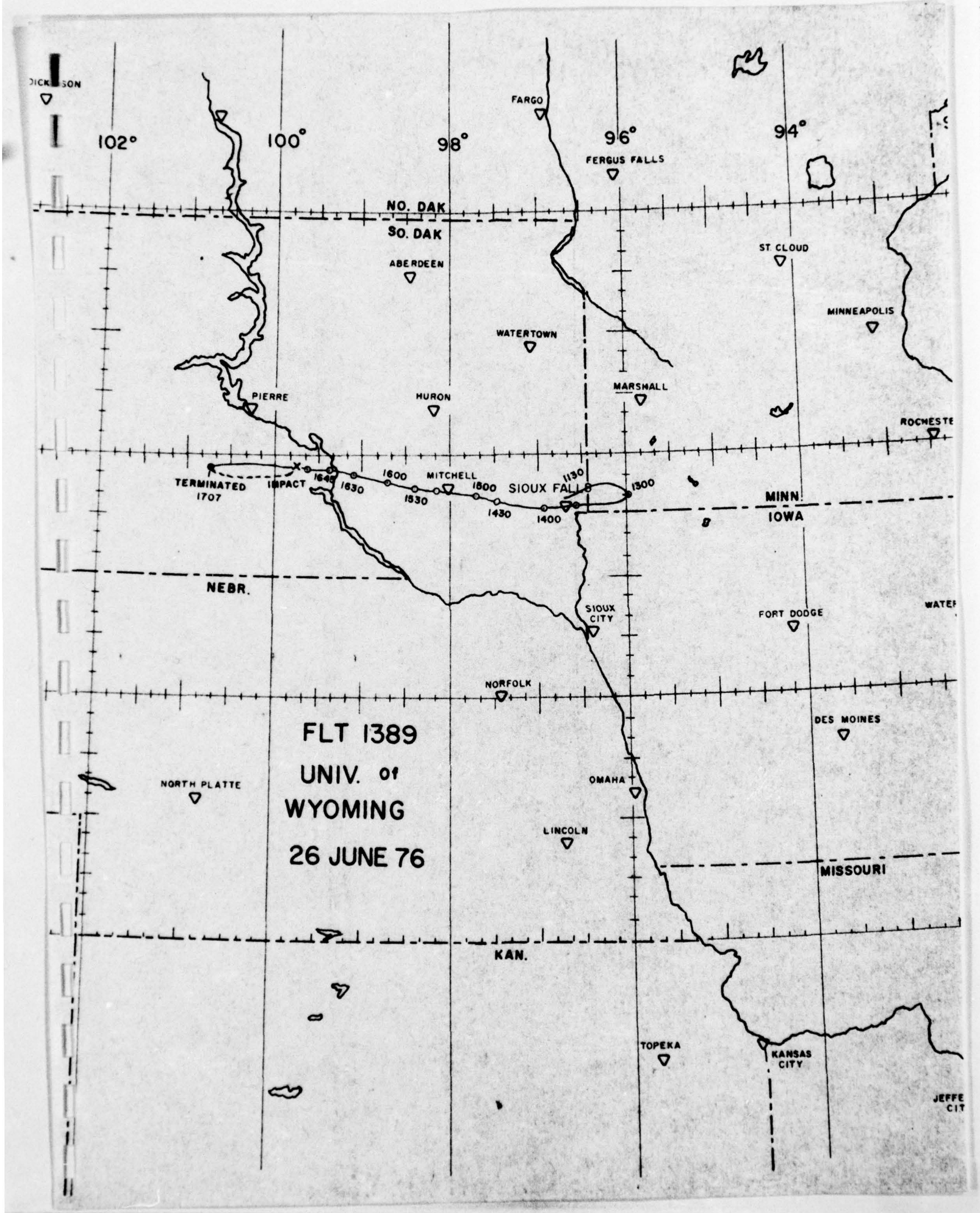
Due to problems in the scientific package and preparations to terminate the flight, no further ranging and commands were transmitted on this flight.

TABLE 12 - DATA

TIME	RAVEN RANGE	-006 RANGE	-006 TEMP	-007 RANGE	-007 TEMP	-008 RANGE	-008 TEMP
0251	5	5	4.85	5	4.85	5	4.95
0300		NA	4.85	NA	4.85	NA	4.95
0330		NA	4.75	NA	4.72	NA	4.85
0400	26	25	4.4	25	4.42	17	4.6
0430	24	27	4.1	27	4.05	27	4.25
0500	25	26	3.8	26	3.8	26	4.0
0530	30	32	3.55	33	3.5	32	3.7
0600	36	35	3.3	35	3.2	33	3.45
0630	52	55	3.05	55	2.9	56	3.2
0700	55	55	2.85	57	2.7	58	2.9
0730	64	60	2.65	60	2.5	60	2.8
0800	NO DATA						
0830	74	76	2.45	77	2.3	77	2.55
0900	80	85	1.95	85	1.85	85	2.10
0930	83	85	1.75	85	1.7	85	1.85
1000	91	85	1.55	90	1.5	95	1.70
1030	93	90	1.45	95	1.4	95	1.55
1100	98	100	1.35	95	1.3	90	1.45
1130	108	105	1.35	110	1.3	110	1.45
1200		NA	1.55	NA	1.35	NA	1.7
1230	112	115	1.8	115	1.65	115	1.95
1300		NA	2.05	NA	1.90	NA	2.15
1330	126	125	2.3	120	2.1	120	2.35
1400	129	125	2.5	130	2.3	125	2.6
1430	135	135	2.65	135	2.4	135	2.8
1500	142	150	2.75	145	2.55	142	3.0
1508	TERMINATE FLIGHT						

TABLE 13 - DATA

TIME	RAVEN RANGE	-002 RANGE	-002 TEMP	-010 RANGE	-010 TEMP	-009 RANGE	-009 TEMP
1129	5	5	4.7	5	4.95	5	4.8
1200	12		4.6	16	4.85	14	4.7
1230	31		4.45	31	4.85	31	4.7
1300	31		4.45	30	4.7	30	4.5
1330	30		4.1	27	4.3	30	4.1
1400	26	Automatic Data Not Available Due To S/N Ratio	4.1	22	4.3	NA	4.05
1430	20		4.2	21	4.3	NA	3.95
1500	19		4.25	NA	4.3	NA	3.90
1530	22		4.25	23	4.3	23	3.90
1600	25		4.3	NA	4.25	NA	3.80
1630	29		4.3	33	4.25	29	3.70
1700	34		4.3	NA	4.3	NA	3.70
1730	40		4.25	NA	4.3	NA	3.85
1800	48		4.2	NA	4.3	NA	3.9
1830	58		4.2	60	4.25	60	3.9
1900	67		4.3	68	4.25	68	3.85
1930	72		4.25	74	4.3	78	3.85
2000	82		4.25	84	4.3	NA	3.90
2030	87		4.25	88	4.3	NA	3.90
2100	93		4.25	94	4.25	NA	3.90
	T E R M I N A T I O N	@	2100Z				
2115	90 40K FT		4.2	93	4.2	NA	3.8
2130	NA 15K FT		3.9		3.9		3.5
2140	NA 10K FT		3.9		3.9		3.5



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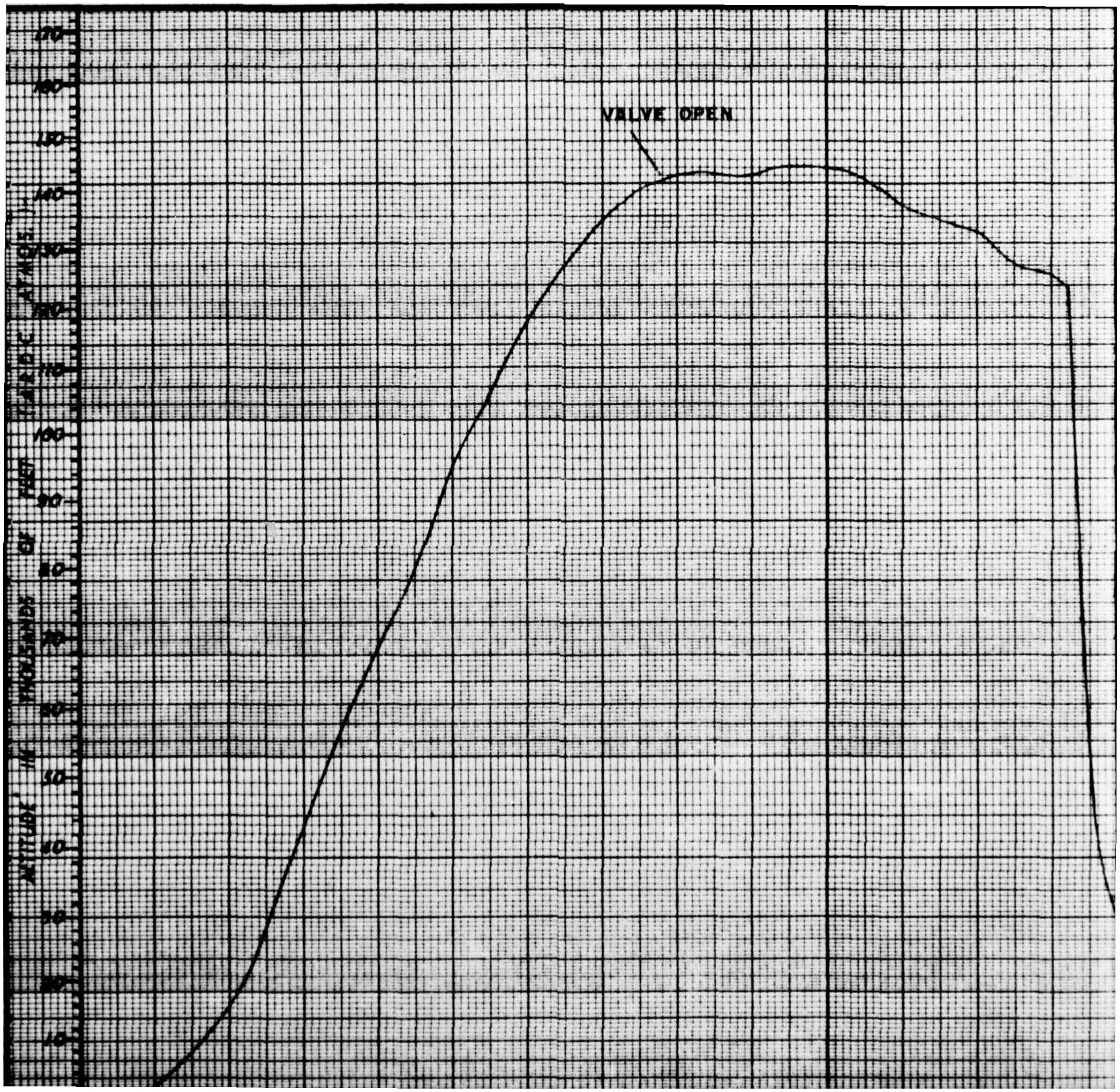
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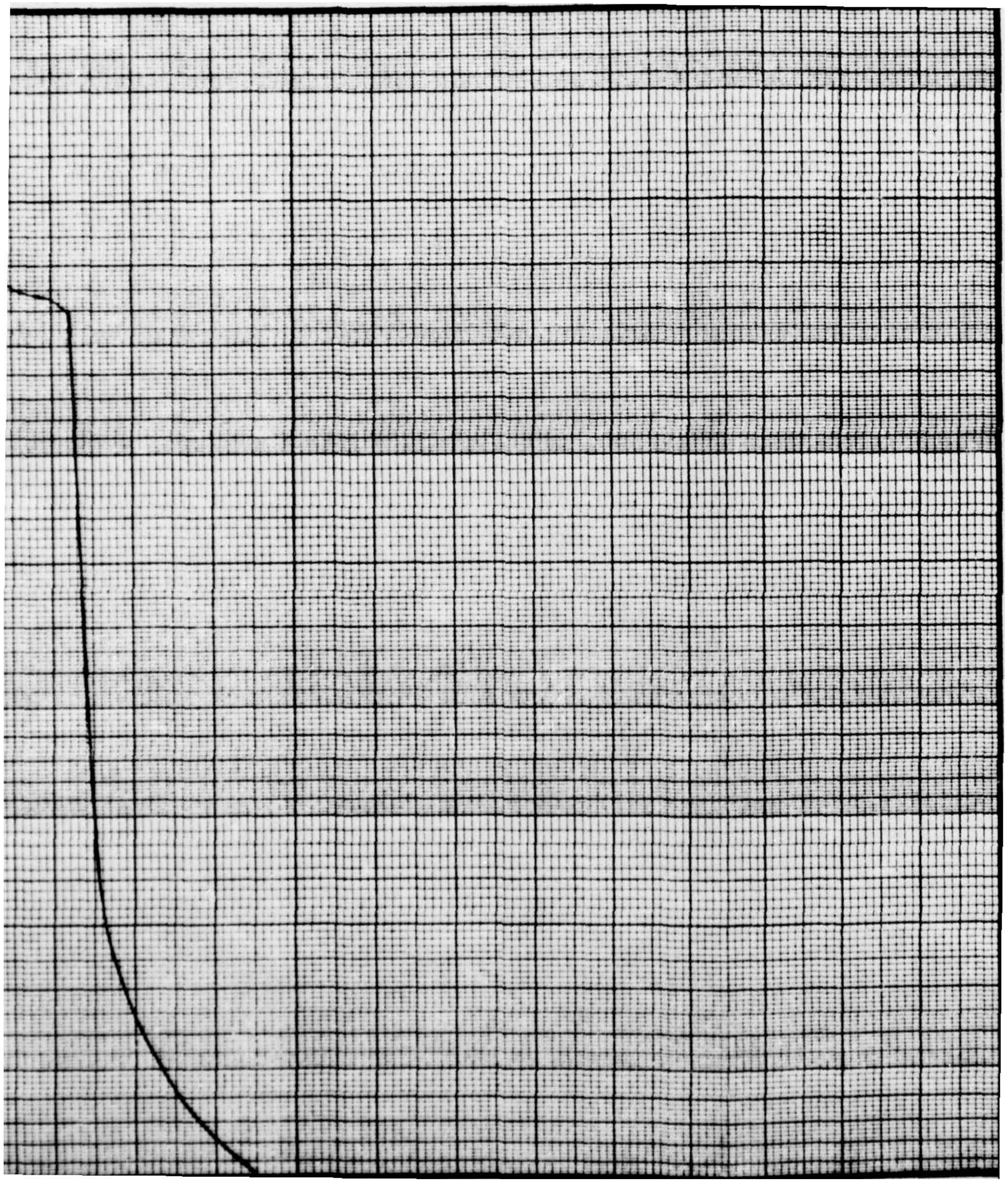

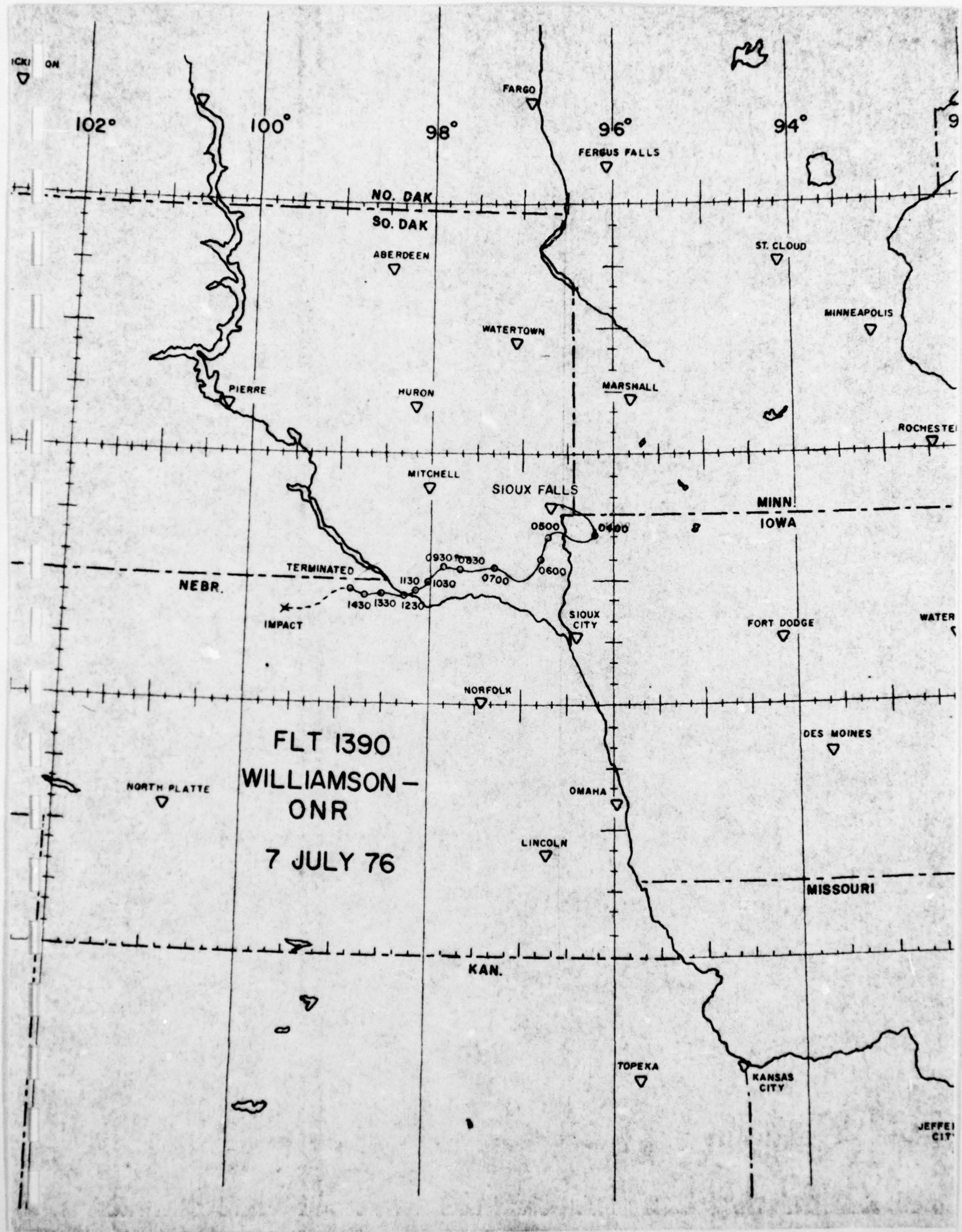

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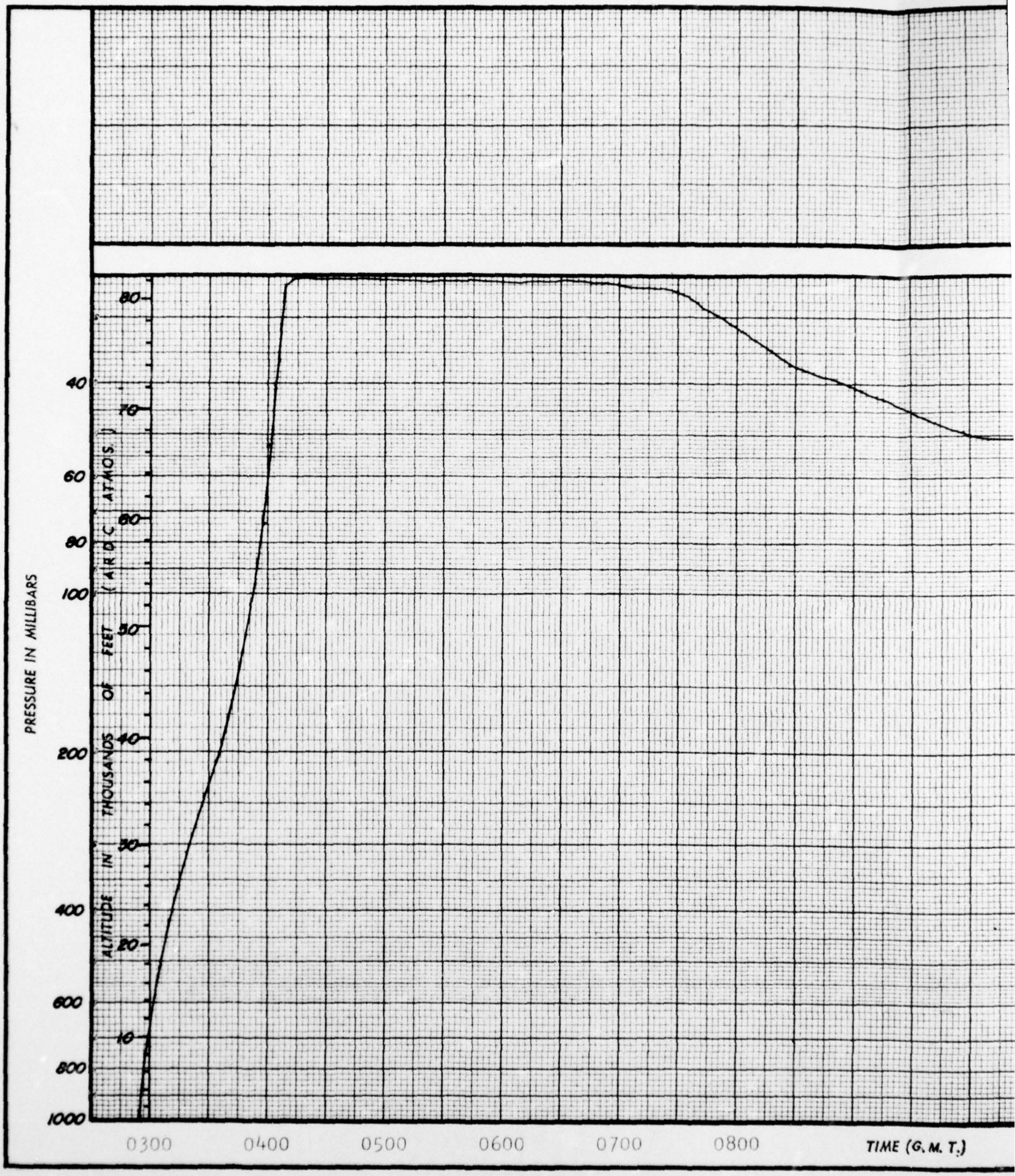
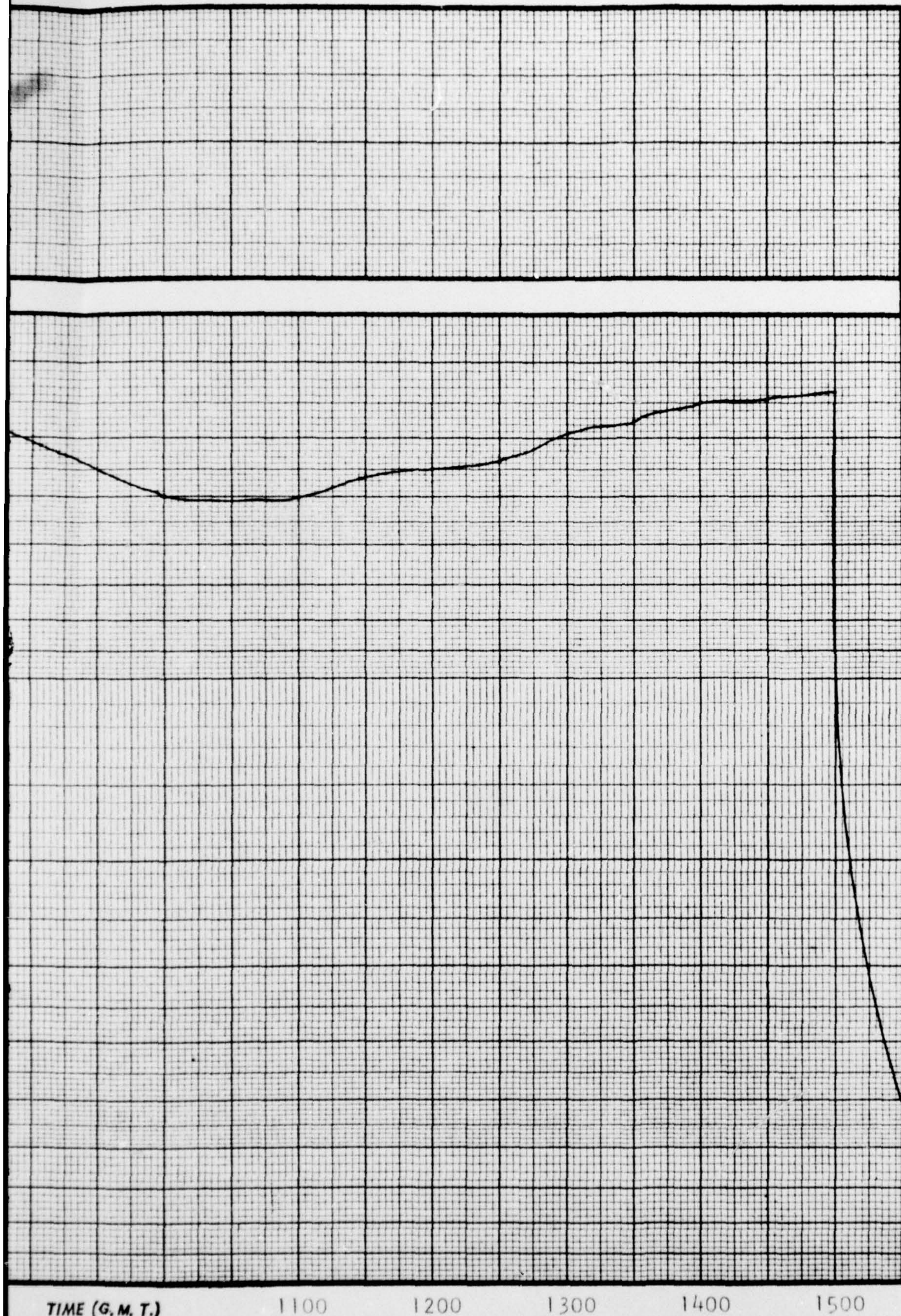


PRESSURE IN MILLIBARS
ALTITUDE IN THOUSANDS OF FEET (A R D C ATMOS.)
40
60
80
100
200
400
600
800
1000
80
70
60
50
40
30
20
10
0300
0400
0500
0600
0700
0800
TIME (G. M. T.)



FLIGHT NO. 1390

DATE: 8 JULY 1976

FOR: ONR and WILLIAMSON TEST FLIGHT

BALLOON

TYPE: NSC

VOL: 80,000 CU.FT.

MATL: STRATOFILM

WT: 45 LBS.

LOAD FACTORS (LBS.)

PAYLOAD: 145

GROSS LD: 190

FREE LIFT: 48

BALLAST: 0

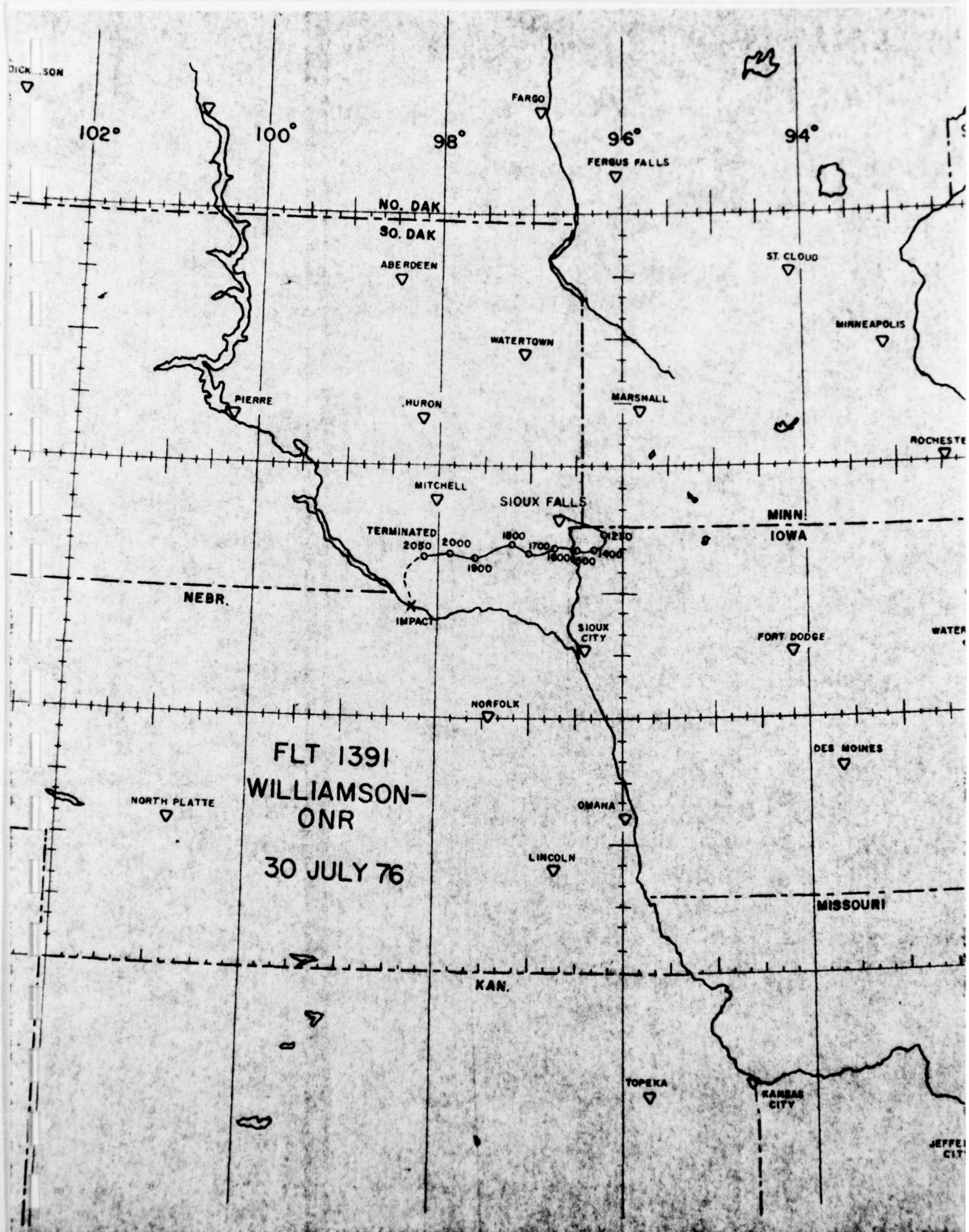
RAVEN industries, inc.

DR. ____________

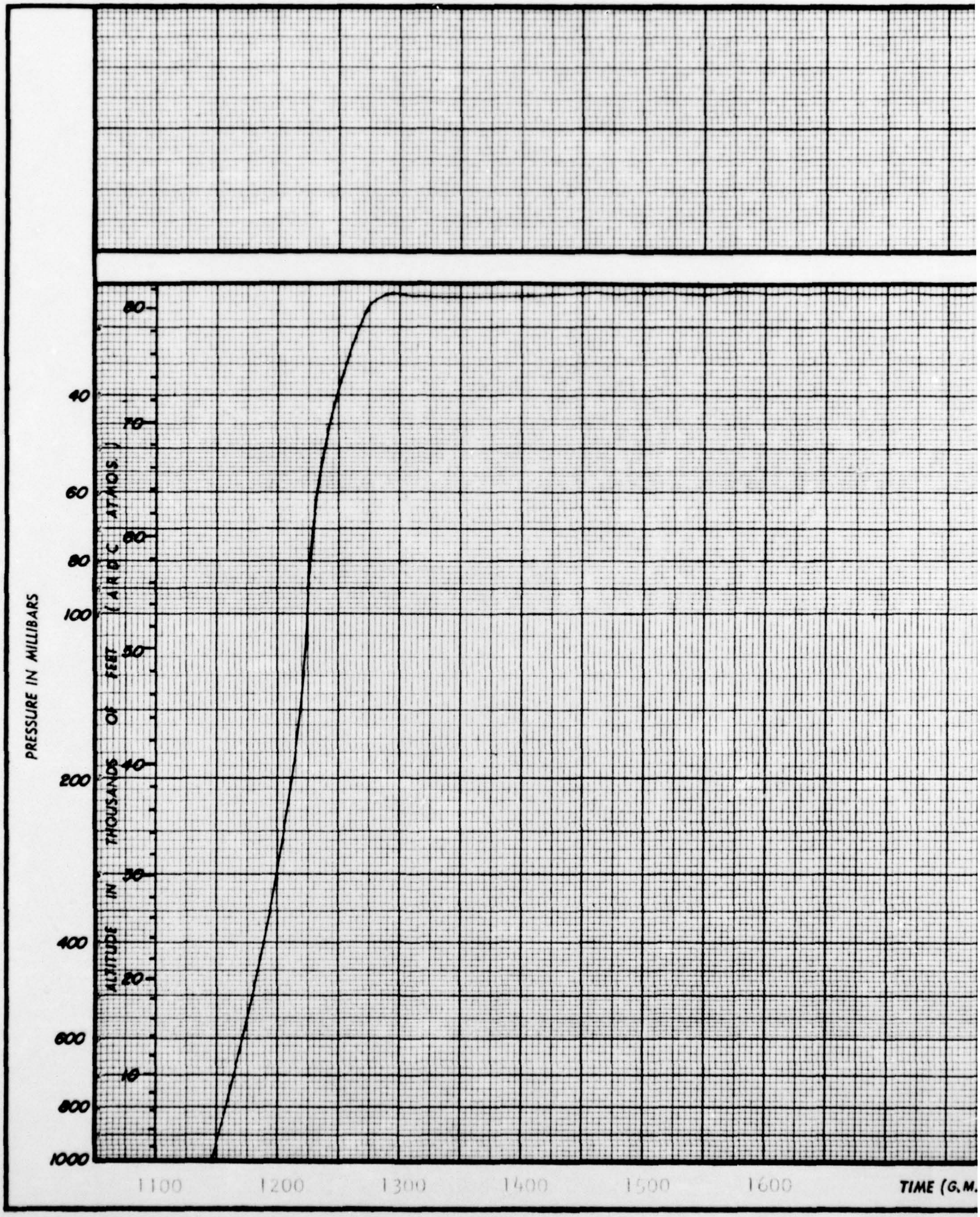
CHK. ____________

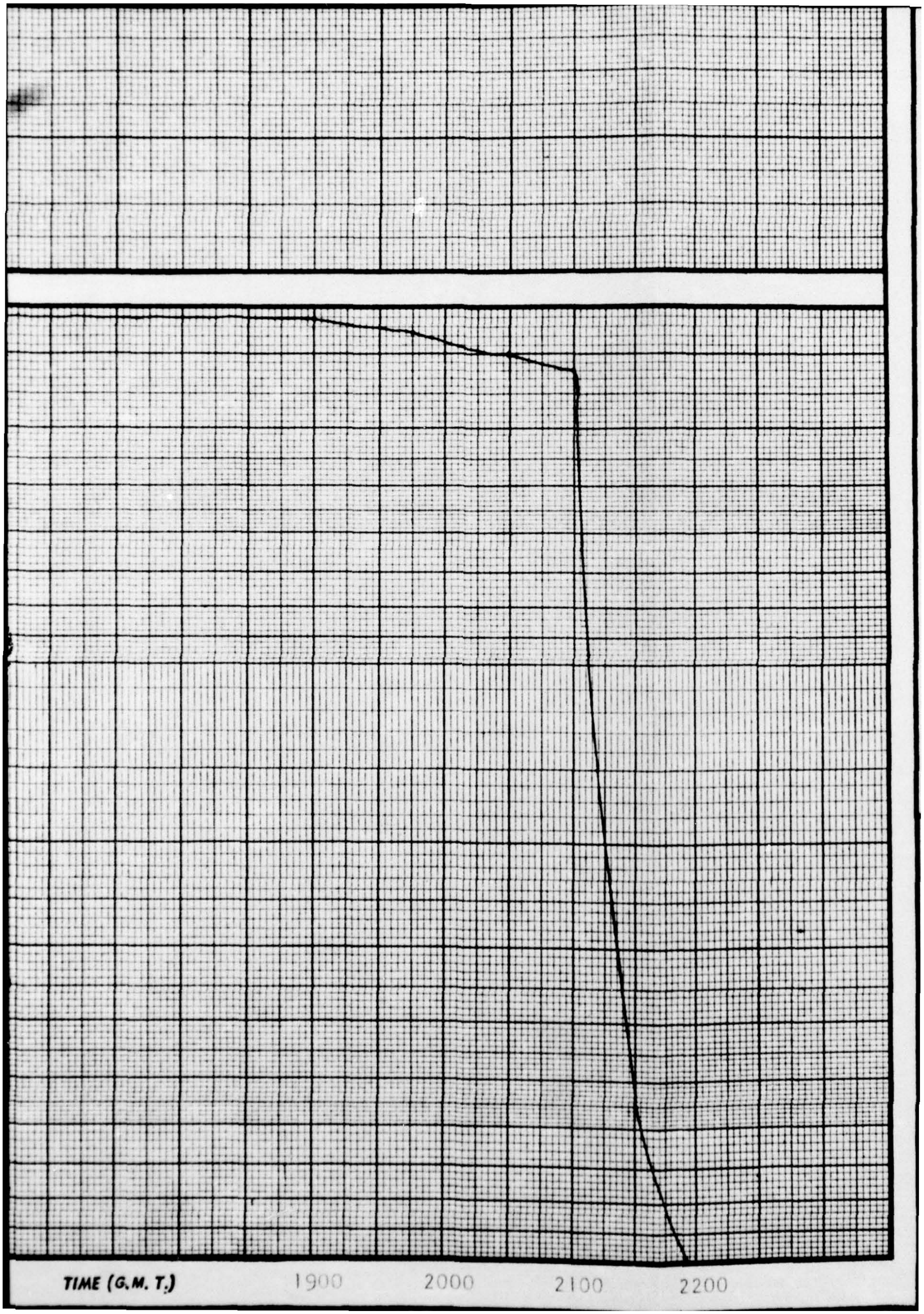
APPR. ____________

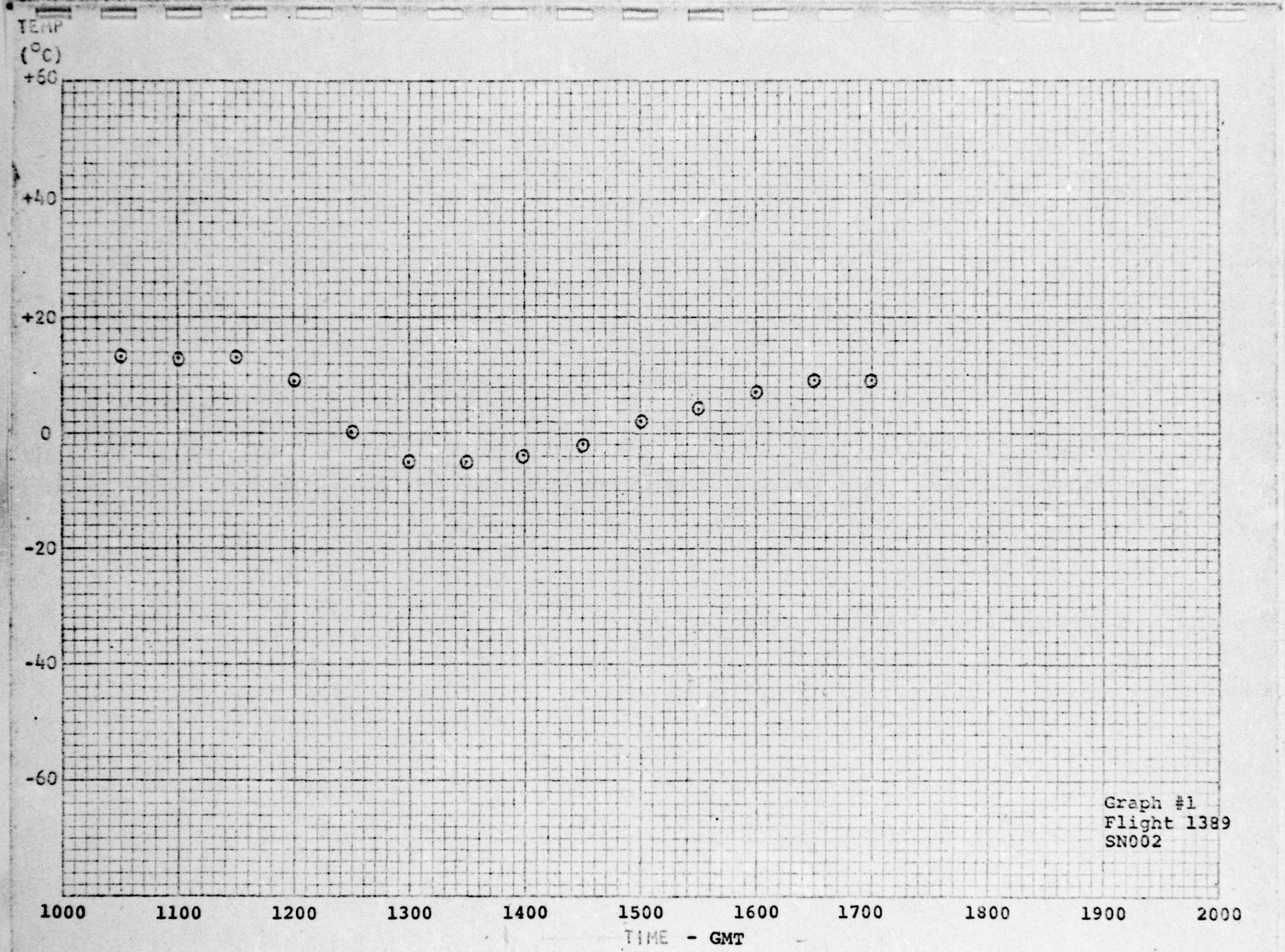
STANDARD BLUE PRINT, OMAHA 100163

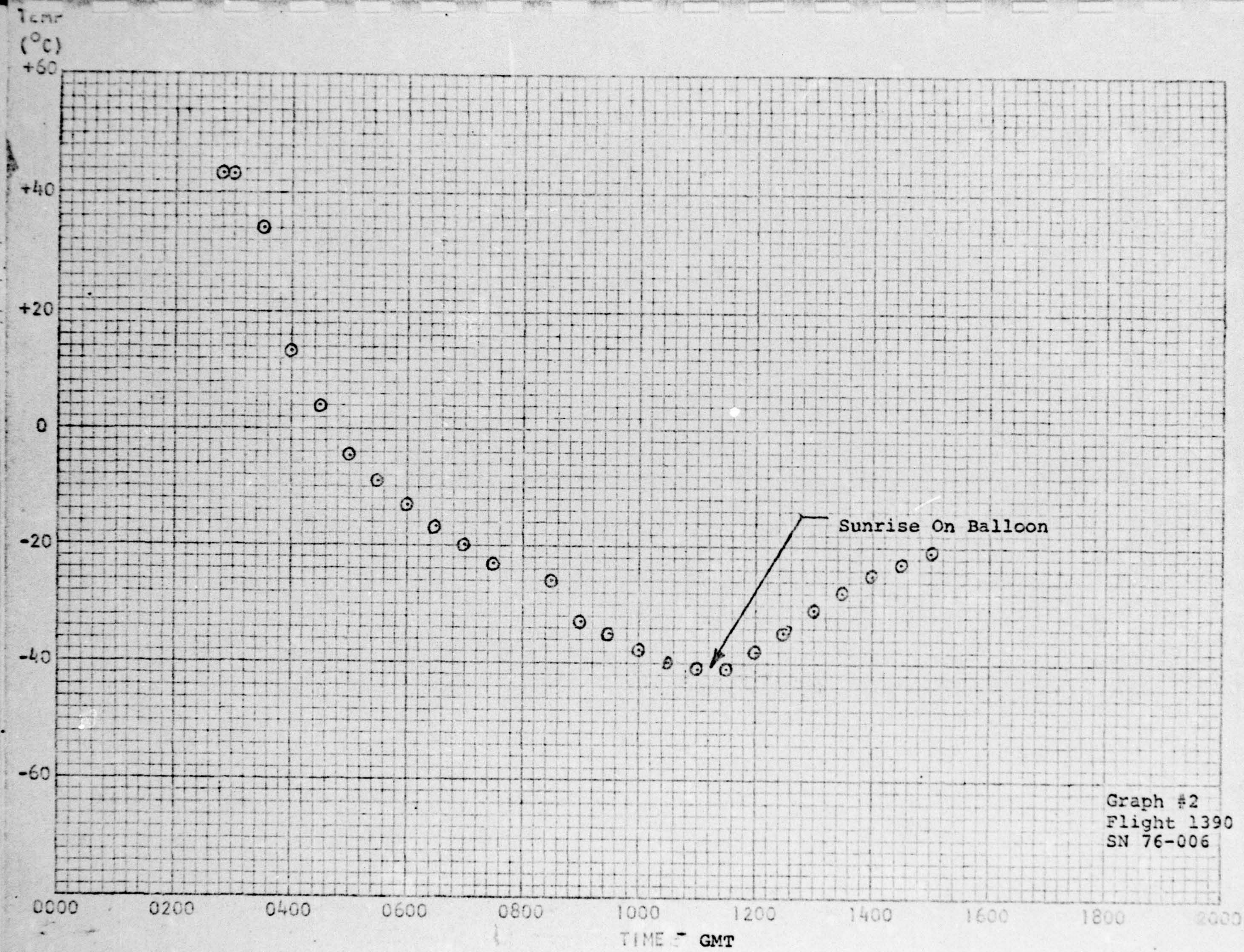


DICK..SON
FARGO
102°
100°
98°
96°
94°
FERGUS FALLS
NO. DAK
SO. DAK
ABERDEEN
ST. CLOUD
MINNEAPOLIS
WATERTOWN
PIERRE
HURON
MARSHALL
MITCHELL
SIOUX FALLS
MINN.
IOWA
TERMINATED
2050
2000
1900
1800
1700
1600
1500
1400
1230
NEBR.
IMPACT
SIOUX CITY
FORT DODGE
NORFOLK
DES MOINES
FLT 1391
WILLIAMSON-ONR
30 JULY 76
NORTH PLATTE
OMAHA
LINCOLN
MISSOURI
KAN.
TOPEKA
KANSAS CITY

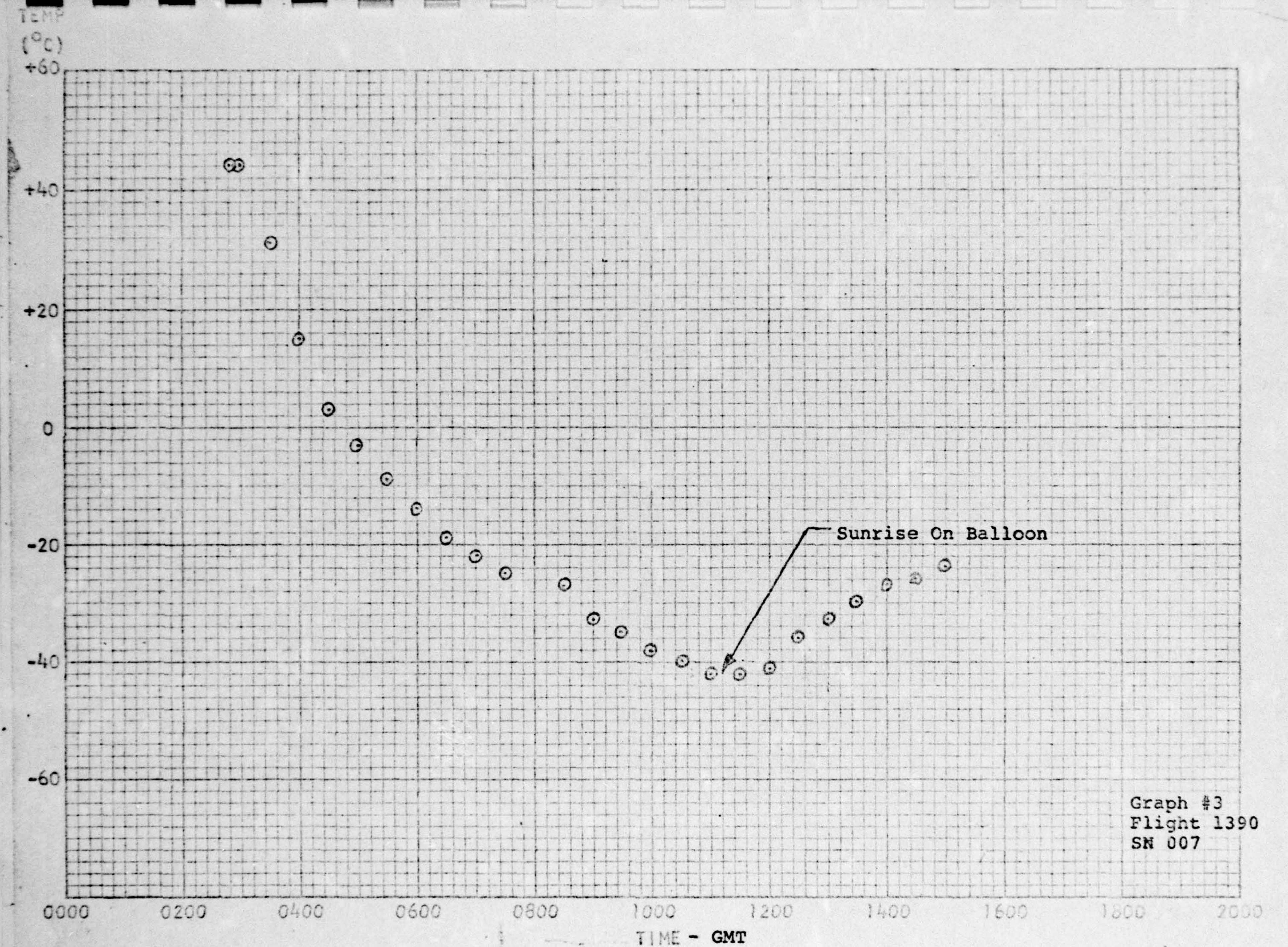

PRESSURE IN MILLIBARS
40
60
80
100
200
400
600
800
1000
ALTITUDE IN THOUSANDS OF FEET (ARDC ATMOS.)
80
70
60
50
40
30
20
10
1100
1200
1300
1400
1500
1600
TIME (G.M.

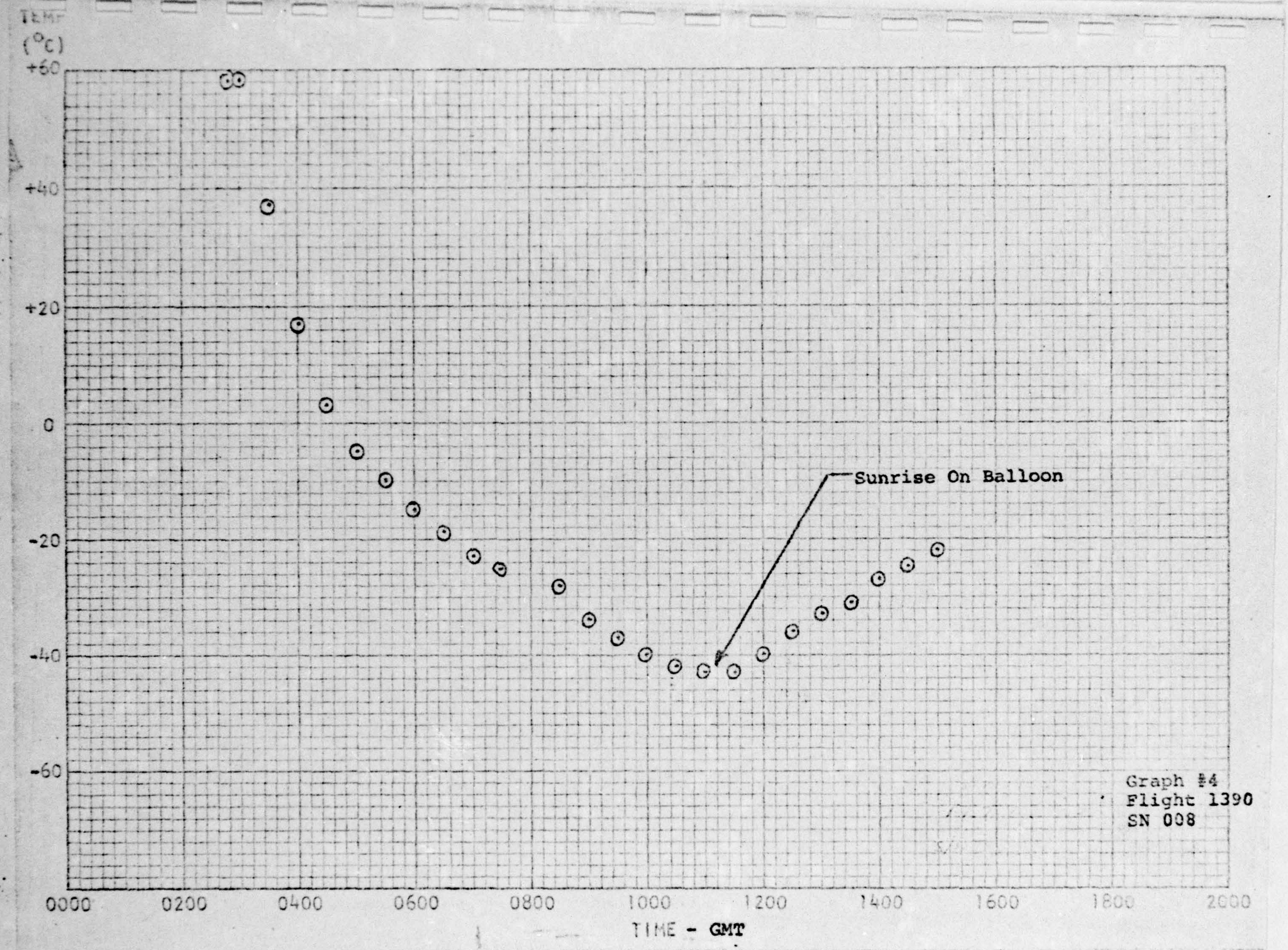

TIME (G.M. T.)
1900
2000
2100
2200


TEMP
(°C)
+60
+40
+20
0
-20
-40
-60
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
TIME - GMT
Graph #1
Flight 1389
SN002

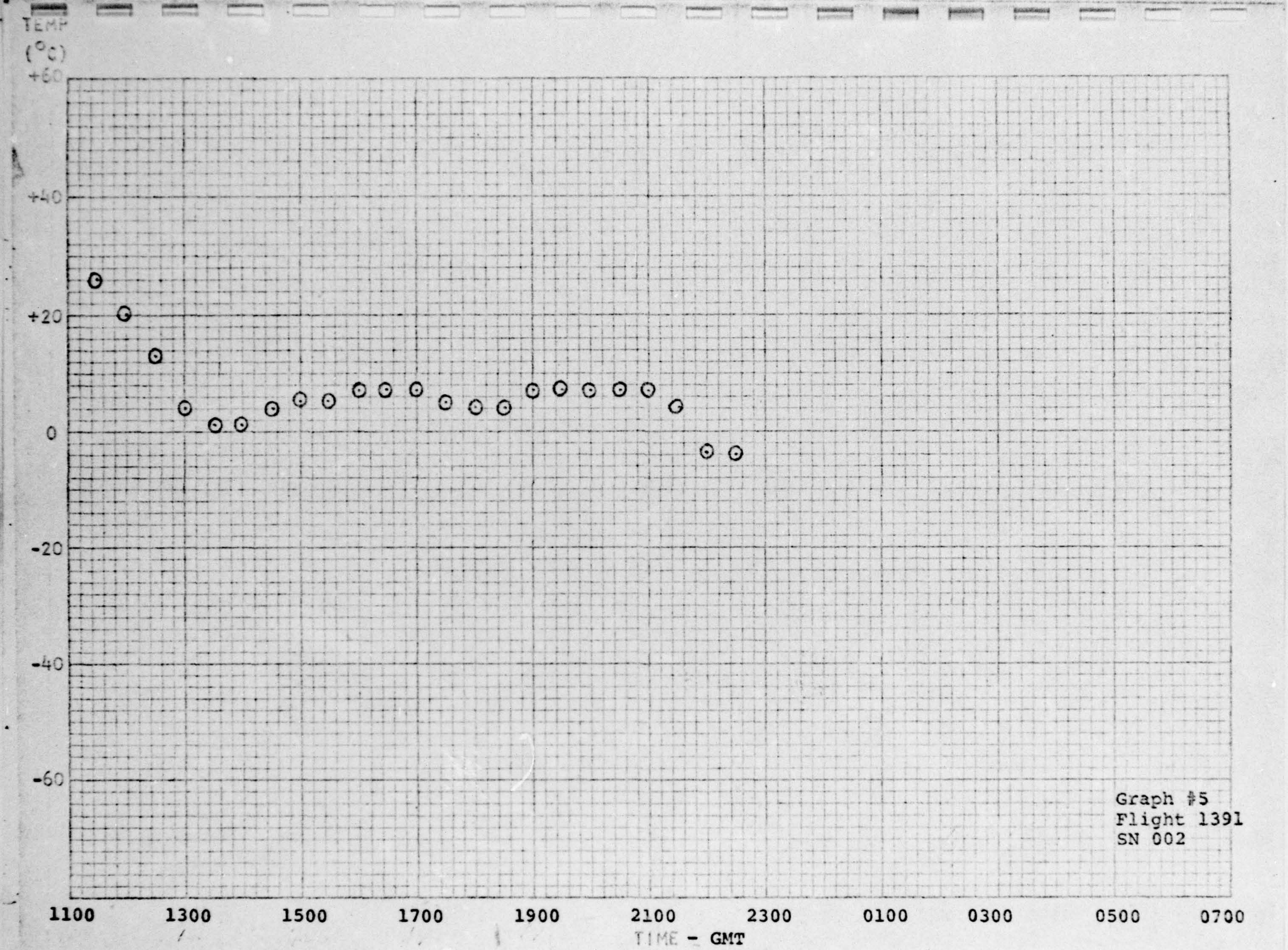


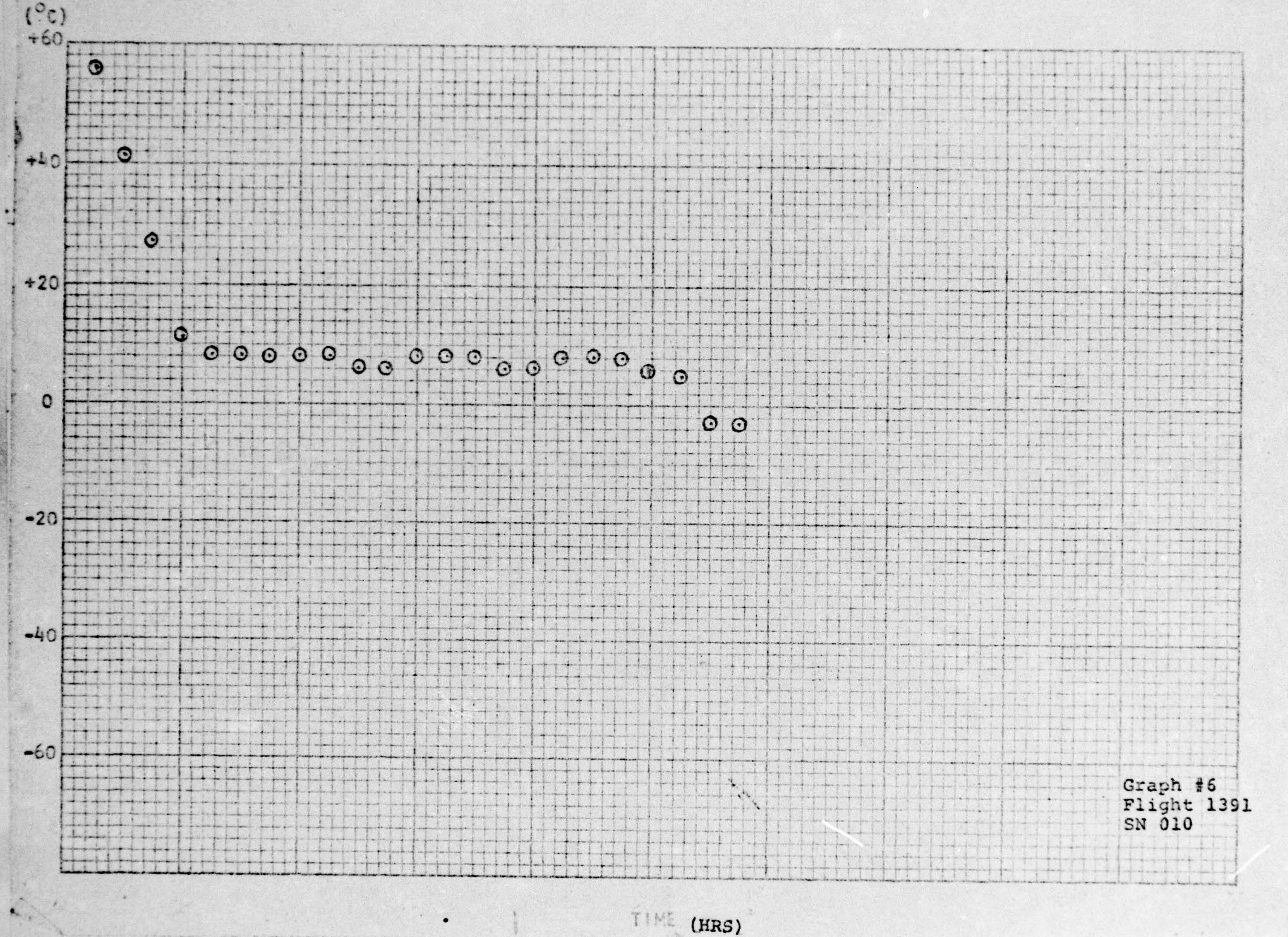
Graph #2
Flight 1390
SN 76-006


TEMP
(°C)
+60
+40
+20
0
-20
-40
-60
Sunrise On Balloon
Graph #3
Flight 1390
SN 007
0000
0200
0400
0600
0800
1000
1200
1400
1600
1800
2000
TIME - GMT



TEMP
(°C)
+60
+40
+20
0
-20
-40
-60
Sunrise On Balloon
Graph #4
Flight 1390
SN 008
0000
0200
0400
0600
0800
1000
1200
1400
1600
1800
2000
TIME - GMT


TEMP
(°C)
+60
+40
+20
0
-20
-40
-60
1100
1300
1500
1700
1900
2100
2300
0100
0300
0500
0700
TIME - GMT
Graph #5
Flight 1391
SN 002


(°C)
+60
+40
+20
0
-20
-40
-60
TIME (HRS)
Graph #6
Flight 1391
SN 010